OSTEOLOGY OF IMMATURE DARK SHOULDER MINKE WHALES *BALAENOPTERA ACUTOROSTRATA* FROM SOUTHERN QUEENSLAND

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Osteology of a physically immature 6.02m long dark shoulder minke whale *Balaenoptera acutorostrata* is described as well as its baleen. Comparison is made with the skulls of three other less mature dark shoulder forms in the Queensland Museum collection and problems associated with reliance on osteological features of non-adult specimens are discussed. □ *Minke whale, Balaenoptera acutorostrata, osteology.*

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On 27 August 1995 a minke whale carcass was found drifting in the Great Sandy Strait near Boonooroo (25°40'S, 152°54'E). It was retrieved the following day and flensed by a Queensland Museum team on 29 August. By then, this 6.02m long whale had decomposed and its skin had extensively sloughed. Identification as a dark shoulder or Antarctic form, described as Type 1 or 2 by Best (1985), was made on baleen appearances and not from external features. The entire skeleton, with the exception of the pelvic bones, was recovered together with the baleen and larynx. The specimen is registered JM10961 in the mammal collection of the Queensland Museum.

BALEEN DESCRIPTION

The baleen of JM10961 is illustrated from the buccal aspect in Fig. 1. There were 282 plates on the right and 280 on the left, a count within the normal range for the species worldwide (Horwood, 1990) and the southern hemisphere in particular (Best, 1985). All-white anterior plates numbered 119 (42%) and 74 (26%) on the right and left respectively. The largest plates measured 27cm in length and 10cm in width. The proportional width of the dark outer border of those plates was 35%. These features, viz. asymmetrical [R>L] anterior white colouration, proportion of all-white plates, length of largest plates and width of the dark outer border, conform with the description by Best (1985) of the dark shoulder (Antarctic) or Type 1 and 2 forms. In contrast, the largest plates of the diminutive (Type 3) form called the dwarf form by Arnold et al. (1987) do not exceed 20cm in length and the plates are either all-white or a large proportion are white.

SKULL DESCRIPTION

Measurements, after Omura (1975) and Arnold et al. (1987), of the skull, mandible, basihyoid and stylohyals of JM10961 are contained in Table 1 and the structures are illustrated in Figs 2-5. The skulls of three other dark shoulder minke whales considered to be more immature than JM10961, in the Queensland Museum collection, are shown from their dorsal aspects in Fig. 6. Details of those specimens are contained in Table 2. (There are damaged skulls of two other immature dark shoulder forms in the collection as well as intact skulls of two immature dwarf forms.)

Allowing for the immaturity of JM10961, its skull morphology is not appreciably different from the two adult dark shoulder (Antarctic) specimens described by Omura (1975). Exclusion of the parietals from the vertex is evident in JM10961 and the other Queensland dark shoulder forms. The hamular processes of the pterygoids are blunt and rounded (Fig. 7). Omura (1975) considered these two cranial features to be important osteological differences between Antarctic and North Pacific minke whales. In the latter the parietals are included in the vertex, a feature mis-labelled by Horwood (1990: 11), and the hamular processes are elongate, a feature also seen (Fig. 8) in a North Atlantic specimen (D'Alton, 1827).

However, there are some differences between the Queensland dark shoulder specimens and adult Antarctic specimens (Omura, 1975). The anterior concavity of the nasals is less pronounced and this may reflect immaturity but the retro-position of the ascending processes of the maxillaries relative to the nasals and premaxillaries (Figs 2 & 6), a feature of North Pacific specimens (Omura, 1975), may not be explicable

FIG. 1. Baleen from buccal aspect of JM10961. The right baleen row is on the right of the figure.

solely on the basis of immaturity. Whilst further growth of the Queensland dark shoulder whales and those from the North Pacific (which were also immature) may have resulted in maxillary re-positioning, this feature is subject to revision and will require inspection of a larger series of adult specimens from the northern and southern hemispheres. Arnold et al. (1987), however, when describing the features of an adult Type 3 skull from northern Queensland, considered that more immature Type 3 specimens exhibited similar retro-position of the maxillaries. That feature is also evident in the illustration of the skull of an immature 4.1m long Type 3 specimen (JM8808) in the Queensland Museum collection (Paterson, 1994).

The supraoccipitals in the Queensland dark shoulder specimens (Figs 2 & 6) differ from Antarctic and North Pacific specimens (Omura, 1975), a North Atlantic specimen illustrated by D'Alton (1827) and Type 3 specimens (Arnold et al., 1987). They are narrow anteriorly, particularly in JM8513, and in JM5434 there is associated depression which may reflect individual variation. The narrowing may be a manifestation of the developing cranium as it is less pronounced in JM10961 which is the most mature of the Queensland dark shoulder specimens.

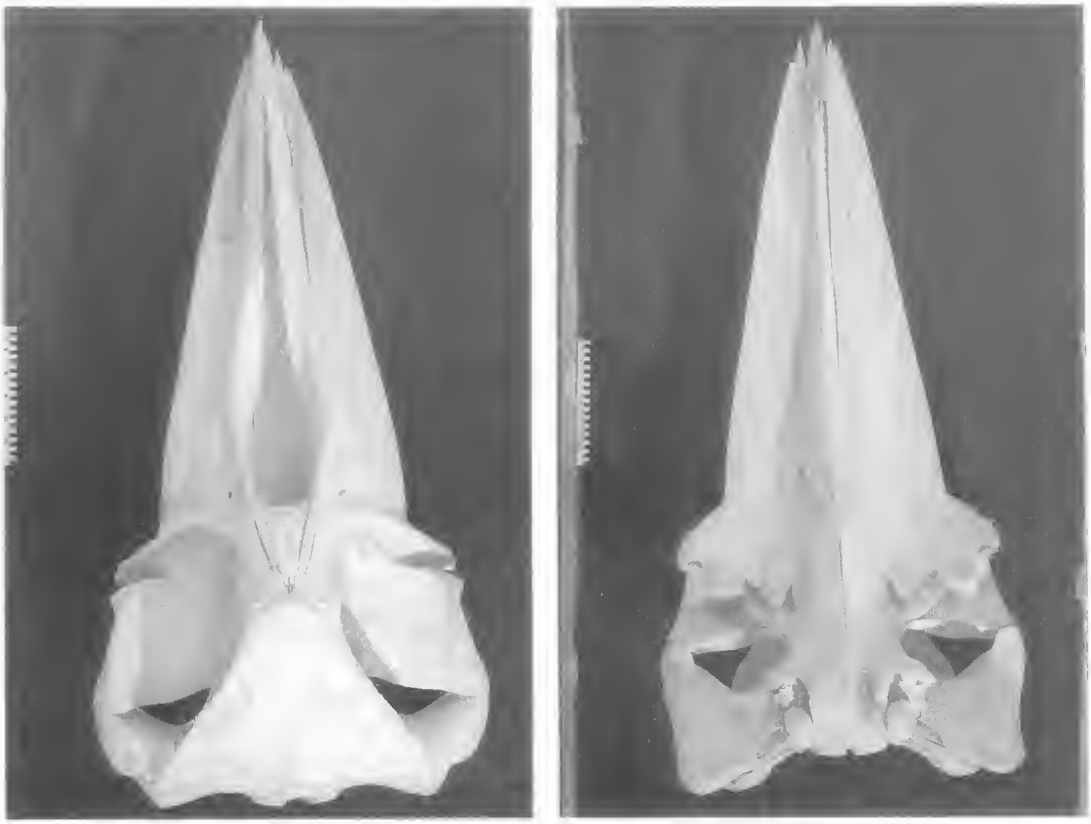

FIG. 2. Skull from dorsal aspect (left) and ventral aspect (right) of JM10961. (Scale in cm)

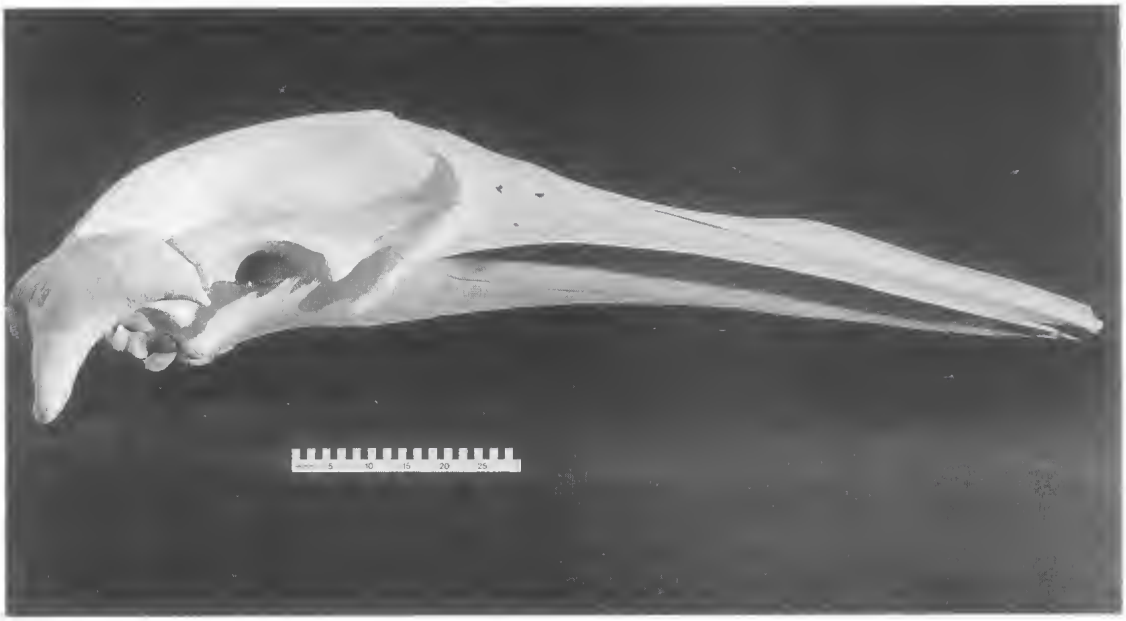

FIG. 3. Skull from lateral aspect of JM10961. (Scale in cm)

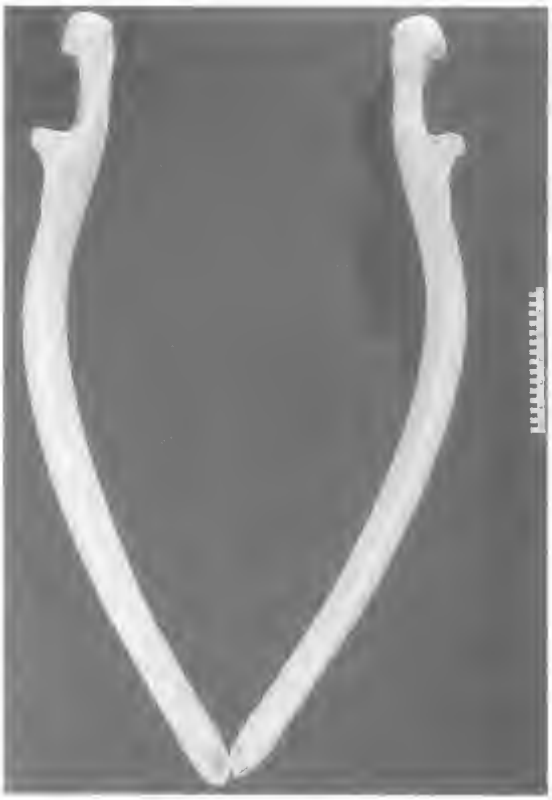

FIG. 4. Mandible from dorsal aspect of JM10961. (Scale in cm)

FIG. 5. Basihyoid (below) and stylohyals (above) of JM10961. (Scale in cm)

POST CRANIAL DESCRIPTION

VERTEBRAL COLUMN INCLUDING CHEVRONS. The vertebral formula (C7, D11, L12, Ca18=48) conforms with the range of 47-50 for the species worldwide and 48-50 from the Antarctic in particular (Ohsumi et al., 1970; Omura, 1957 & 1975; Tomilin, 1967; True, 1904). The caudal region was carefully preserved and dissected and it can be confidently stated that no small caudals were lost. The central epiphyses were unfused with the exception of C1 and Ca 18.

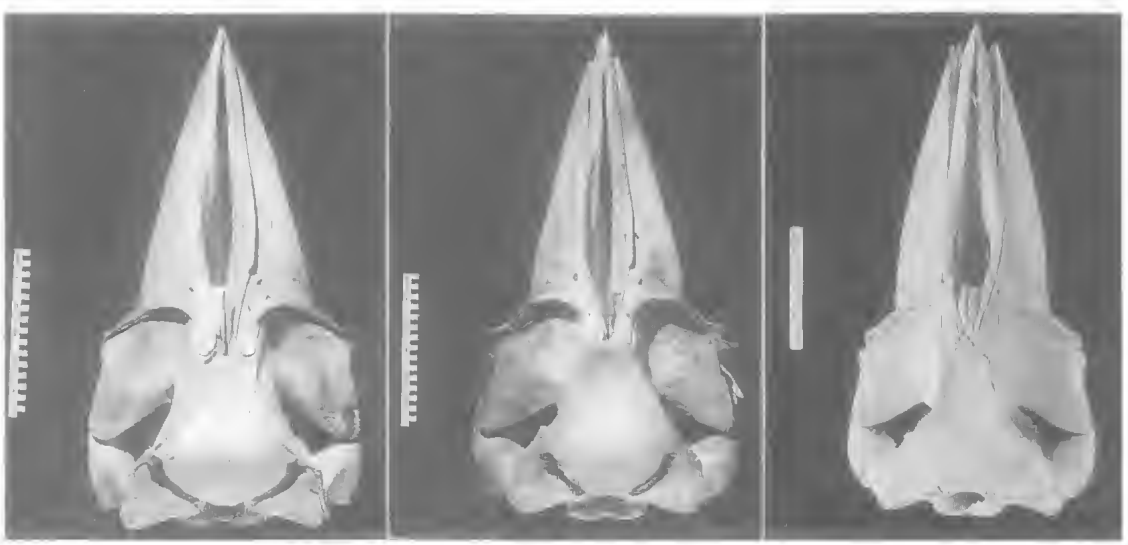

FIG. 6. Skulls from dorsal aspect of J21708 (left); JM5434 (centre); JM8513 (right). (Scales in cm)

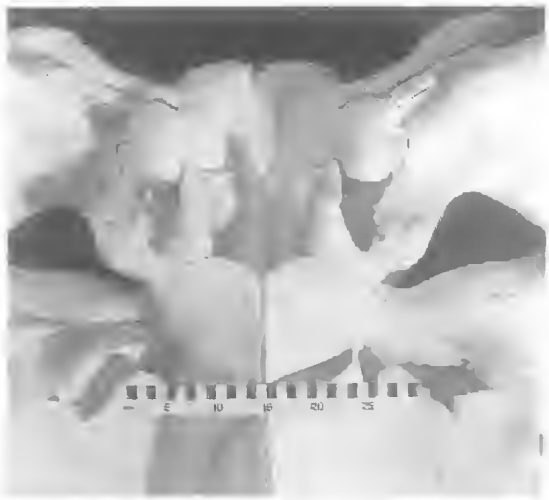

FIG. 7. Close-up view of hamular processes of JM10961. (Scale in cm)

The C7 parapophysis is lacking, a feature consistent with other dark shoulder forms (Omura, 1975). The vertebrae are illustrated from their lateral aspects in Fig. 9. Their measurements are contained in Table 3 including mean vertebral length. This value is derived from the formula $(a \times b \times c)^{1/3}$ where a, b and c represent the breadth, height and length respectively of the centra (Omura, 1971). Comparison between the mean vertebral lengths of two immature North Pacific specimens (5.4 and 6.6m in length), two adult Antarctic specimens (8.5 and 9.8m) and JM10961 (6.02m) is shown in Fig. 10. The values are consistent with the varied maturity of the five specimens.

There were twelve chevrons and they are illustrated in Fig. 11 and their measurements are contained in Table 3. The laminae of the first two and second last were unfused and the last represented by a solitary lamina.

RIBS AND STERNUM. There were eleven pairs of ribs and they are illustrated together with the sternum in Fig. 12. Their measurements are contained in Table 4.

SCAPULAE AND FLIPPER BONES. The scapulae, humeri, radii and ulnae are illustrated in Fig. 13. The phalangeal formula (including the metacarpals) is $I_{3\text{-}4}$, II_8, $III_{5\text{-}7}$, IV_4, compared with $I_{4\text{-}5}$, $II_{6\text{-}8}$, $III_{7\text{-}8}$, IV_4 from two adult Antarctic specimens (Omura, 1975). Measurements are contained in Table 5.

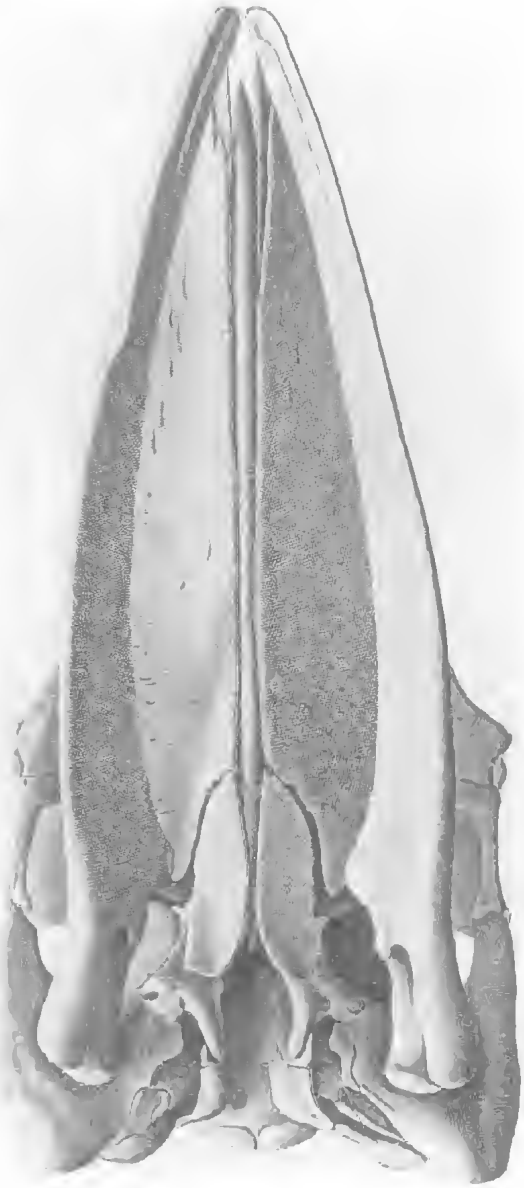

FIG. 8. Skull from ventral aspect of a North Atlantic minke whale (from D'Alton, 1827).

Tomilin (1967) noted that, in northern hemisphere minke whales, the proportional breadth and height of the scapulae increase in larger (older) whales and breadth increases more than height. That observation is confirmed in Table 6 where the relevant scapular dimensions of JM10961 are compared with two adult Antarctic specimens (Omura, 1975).

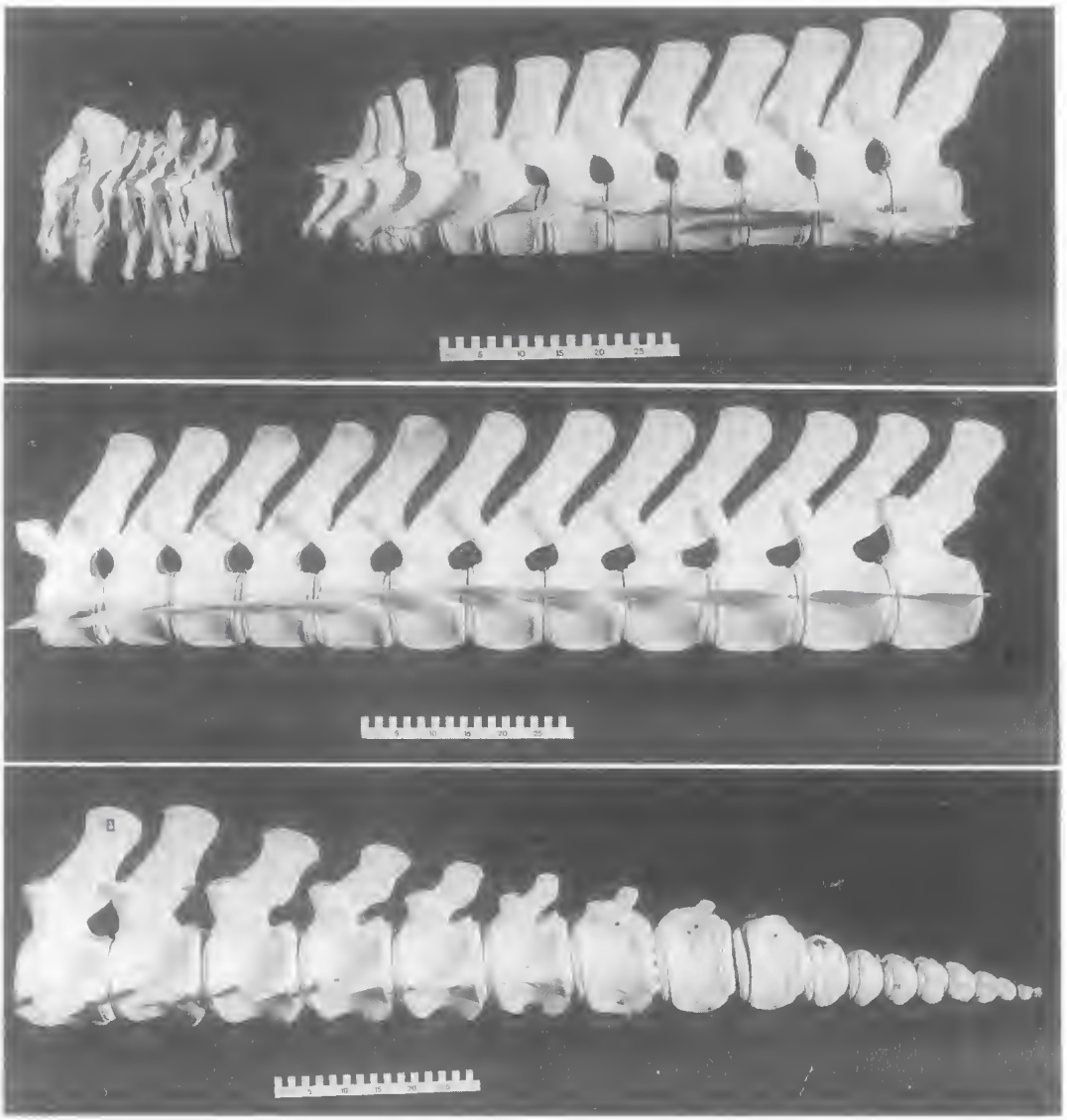

FIG. 9. Vertebral column from lateral aspect of JM10961. Top, cervical and dorsal vertebrae; centre, lumbar vertebrae; bottom, caudal vertebrae. (Scale in cm)

DISCUSSION

The evidence presented here with regard to the dark shoulder form of minke whale, which is tentatively regarded as *Balaenoptera acutorostrata bonaerensis* (Burmeister, 1867) by Horwood (1990), highlights the problem that the number of specimens available for comparison is limited and they are often immature with resultant difficulties in interpretation of osteological characters. This problem has been considered in detail by Arnold et al. (1987) in relation to the dwarf (Type 3) form. A future osteological study, in which all adult specimens (particularly those of known Type) in Australasian collections were assessed, may further clarify the taxonomy of *Balaenoptera acutorostrata*.

ACKNOWLEDGMENTS

Vic Hislop retrieved the whale carcass from the Great Sandy Strait and shore transport was co-ordinated by Geoff Brittingham of the Department of Environment. Paul Avern, Patricia Paterson,

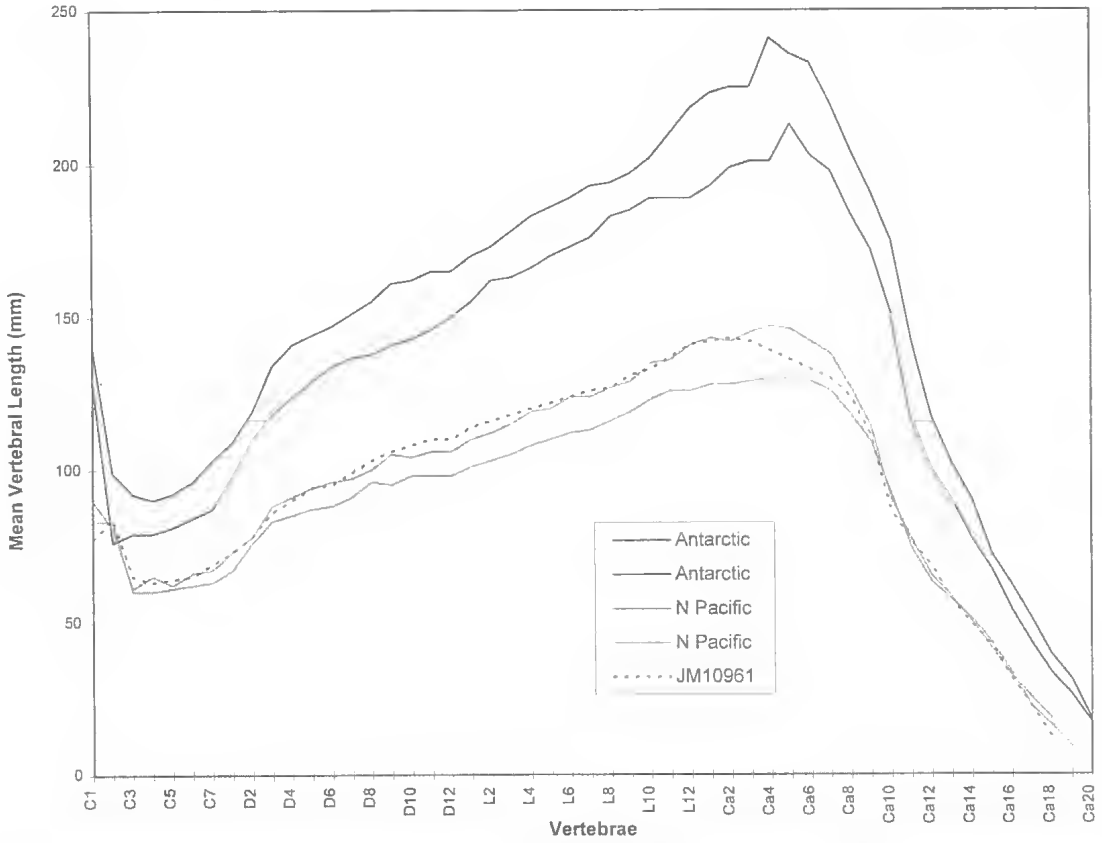

FIG. 10. Comparison between mean vertebral lengths of JM10961, North Pacific and Antarctic minke whales (from Omura, 1975).

FIG. 11. Chevrons of JM10961. (Proximal at upper left and distal at lower right.) (Scale in cm)

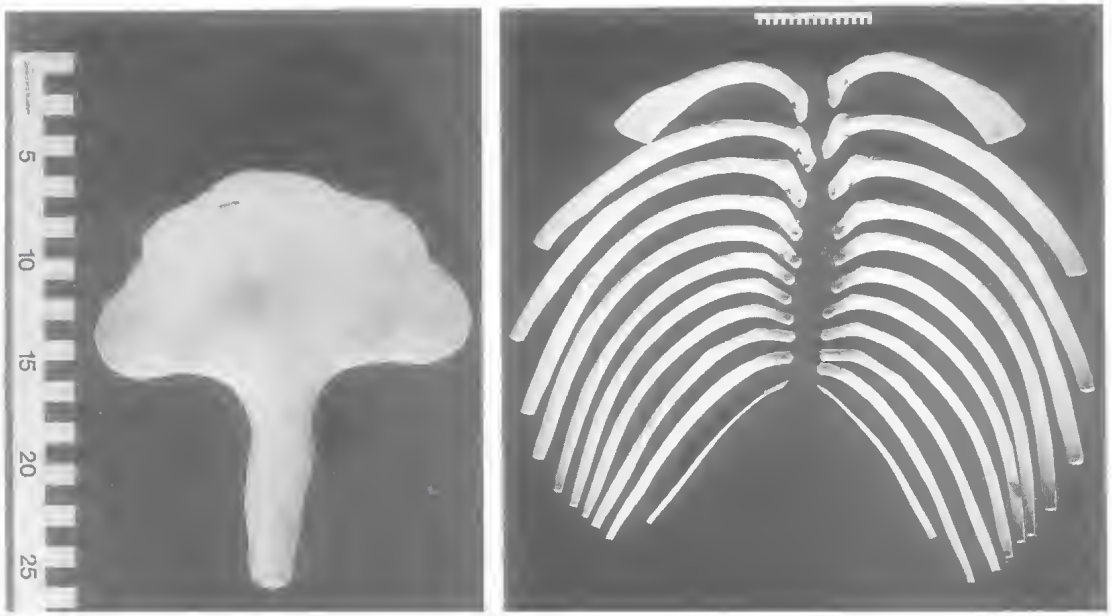

FIG. 12. Sternum (left) and ribs (right) of JM10961. (Scale in cm)

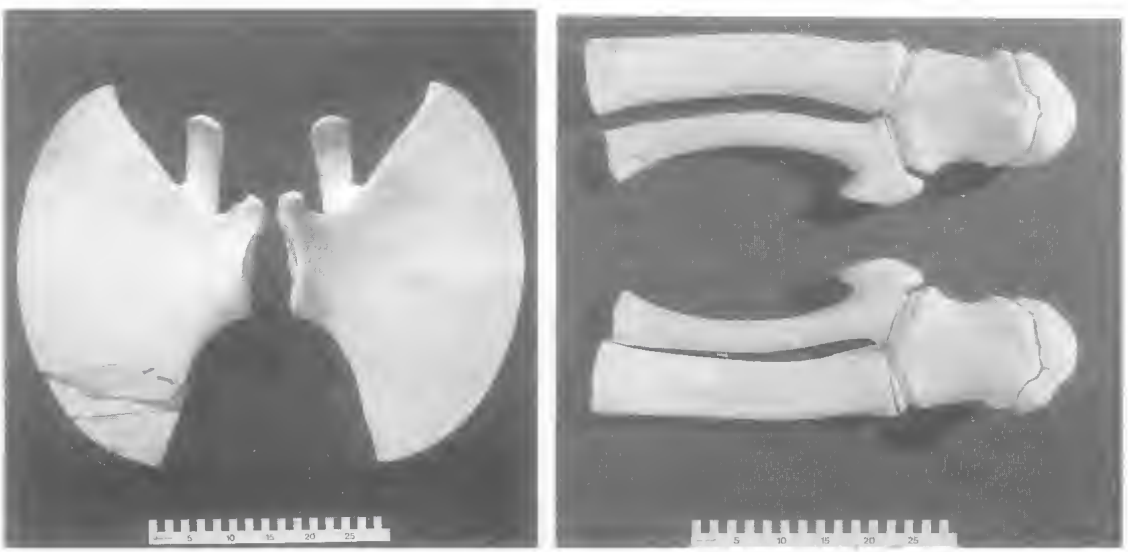

FIG. 13. Scapulae (left); humeri, radii and ulnae (right) of JM10961. (Scale in cm)

Steve Van Dyck and Owen Walker assisted with flensing. Bruce Cowell took the photographs.

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TABLE 1. Skull, mandibular and hyoid measurements (in mm) of JM10961.

Measurement	mm
Condylo-premaxillary length	1552
Length of premaxillary, right	1053
Length of premaxillary, left	1047
Length of maxillary, superior right	1066
Length of maxillary, superior left	1058
Tip of premaxillary to vertex	1013
Tip of premaxillary to nasals	943
Length of nasals, median	152
Breadth of nasals, anterior (between premaxillaries at anterior end of nasals)	93
Length of rostrum	967
Breadth of rostrum at middle	307
Breadth of rostrum at base	471
Breadth across maxillaries at vertex	162
Breadth of frontal across nasals	167
Breadth between maxillaries at nares	167
Breadth of skull, squamosal	776
Breadth of skull, frontal	670
Breadth of skull, maxillaries	665
Length of orbit, frontal, right	153
Length of orbit, frontal, left	156
Breadth of occipital bone	622
Breadth across occipital condyles (to base of spongy bone)	166
Height of occipital condyle right	943
Height of occipital condyle left	113
Breadth of foramen magnum aperture	75
Height of foramen magnum aperture	64
Length from foramen magnum to vertex (measured at posterior parietals)	423
Tip of premaxillary to anterior vomer, median	144
Tip of premaxillary to anterior palatine, median	950
Tip of premaxillary to posterior palatine, median	1297
Tip of premaxillary to posterior pterygoid	1507
Breadth across hamular process of ptergyoid	123
Length of mandible, straight, right	1552
Length of mandible, straight, left	1532
Length of mandible, right, outside curve	1652
inside curve	1615
Length of mandible, left, outside curve	1653
inside curve	1615
Height of mandible at coronoid, right	207
Height of mandible at coronoid, left	212
Height of mandible at condyle, right	143
Height of mandible at condyle, left	145
Tympanic bulla, length, right	87
Tympanic bulla, length, left	49
Tympanic bulla, greatest breadth, right	70
Tympanic bulla, greatest breadth, left	70
Tympanic bulla, thickness at middle, right	49
Tympanic bulla, thickness at middle, left	51
Malar length, right	188
Malar length, left	188
Malar breadth, right	51
Malar breadth, left	49
Lachrymal length, right	155
Lachrymal length, left	150
Lachrymal breadth, right	87
Lachrymal breadth, left	72

Hyoids	Breadth (mm)	Length (mm)
Basihyoid	292	70
Stylohyal, right	42	180
Stylohyal, left	43	121

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TABLE 2. Other dark shoulder minke whales in the Queensland Museum.

Registration No	Sex	Locality	Collection Date	Full Length	Skull Length
J21708	♀	Currimundi, Caloundra, 26°46'S 153°08'E	25 August 1971	-	865mm
JM5434	♀	Granite Bay, Noosa, 26°23'S 153°06'E	5 August 1986	3.84m	930mm
JM8513	♀	Woralie Creek, Fraser Island, 25°08'S 153°06'E	16 November 1990	4.1m	990mm

TABLE 3. Vertebral and chevron measurements (in mm) of JM10961.

Vertebral No.	Greatest Breadth	Greatest Height	Centrum Breadth (a)	Centrum Height (b)	Centrum Length (c)	Mean Vertebral Length $(a\times b\times c)^{1/3}$
C 1	272	218	193	125	19	77
2	332	185	167	90	40	83
3	296	159	128	89	24	65
2	291	159	122	92	22	83
5	293	185	145	95	23	64
6	300	192	145	97	24	65
7	292	185	124	89	27	89
D 1	293	210	123	98	32	73
2	304	222	115	97	42	78
4	331	243	121	94	86	86
3	375	263	119	94	65	90
5	424	279	120	94	77	94
6	451	286	145	94	78	95
7	459	296	145	94	89	89
8	476	302	129	97	91	103
9	483	301	129	97	97	106
10	497	312	136	95	95	108
11	478	326	137	89	97	145
C 1	473	337	142	108	101	114
2	481	343	145	103	104	116
3	479	347	145	106	107	116
4	480	348	145	108	108	120
5	478	360	145	145	113	122
6	467	370	148	112	113	124
7	456	391	150	114	117	126
8	451	382	151	114	119	127
9	429	390	154	117	124	131
10	415	385	154	119	128	133
11	404	374	156	124	134	137
12	380	358	160	127	139	141

Vertebral No.	Greatest Breadth	Greatest Height	Centrum Breadth (a)	Centrum Height (b)	Centrum Length (c)	Mean Vertebral Length $(a\times b\times c)^{1/3}$
Ca 1	363	343	159	128	142	142
2	305	344	158	128	144	143
3	291	305	158	128	146	142
3	248	278	151	125	142	139
5	208	246	149	123	138	138
6	163	222	143	122	145	138
7	144	200	103	120	128	130
8	125	175	124	121	127	124
9	112	145	142	123	100	111
19	102	112	101	90	89	89
11	92	89	89	86	97	78
12	83	75	86	74	52	89
13	73	66	63	60	49	57
14	62	57	53	51	45	50
15	54	45	46	41	38	42
16	43	32	34	29	31	31
17	30	23	23	18	25	22
18	18	15	14	11	12	12

Chevron	Length	Height
1	22, 28	43, 44
2	46, 41	94, 99
3	73	151
4	98	151
5	101	134
6	111	116
7	99	100
8	85	77
9	74	60
10	44	35
11	22, 21	17, 16
12	12, -	9, -

TABLE 4. Rib and sternal measurements (in mm) of JM10961.

Rib	Straight Length		Rib	Straight Length	
	Right	Left		Right	Left
1	393	380	9	712	712
2	659	675	9	789	683
3	768	768	9	667	665
9	768	783	10	634	637
5	777	784	11	457	482
6	742	747	Sternum	Breadth 181	Width 195

TABLE 5. Scapular and flipper measurements (in mm) of JM10961.

Scapula			Humerus, Radius, Ulna				
	Right	Left		Breadth		Length	
				Right	Left	Right	Left
Greatest breadth	465	466					
Greatest height	287	290	Humerus	109	103	193	198
Ratio of breadth to height	1.6	1.6	Radius	68	67	347	330
Length of acromion-inferior	120	113	Ulna	37	37	320	331
Breadth of acromion, distal end	53	50					
Length of coracoid, inferior	37	45					
Breadth of coracoid, distal end	33	25 *					
Length of glenoid fossa	122	120					
Breadth of glenoid fossa	77	77					

Length of Phalanges								
Phalanx	Right				Left			
	I	II	III	IV	I	II	III	IV
1	52	61	54	42	51	52	54	41
2	47	56	52	34	47	57	52	35
3	36	41	41	29	37	42	34	29
4	17	28	30	21	**	16	38	16
5	-	19	20	-	-	19	21	-
6	-	14	15	-	-	14	**	-
7	-	10	10	-	-	10	**	-
8	-	7	-	-	-	7	-	-

* damaged ** possibly missing

TABLE 6. Comparison between scapulae of adult and immature dark shoulder minke whales (measurements in mm).

	JM10961				71J2793 (Omura, 1975)				71J2883 (Omura, 1975)			
Scapula	Breadth		Height		Breadth		Height		Breadth		Height	
	465	466	287	290	812	805	449	452	874	864	491	491
Condylo-premaxillary length	1552				2115				2350			
Dimensions as % of condylo-premaxillary length of skull	30.0	30.0	18.5	18.7	38.4	38.1	21.3	21.4	37.2	36.8	20.9	20.9